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Reconfigured-Channel Monitoring and Assessment Program

A U.S. Geological Survey program to monitor and assess channel reconfiguration activity is described. A data base available on the world wide web will enable land-management agencies and other interested parties to evaluate the long-term success of various channel reconfiguration projects. A demonstration project on the Lake Fork of the Gunnison River, Colorado, illustrates the program objectives and approach.

Introduction

Channel reconfiguration to mitigate a variety of riverine problems has become an important issue in the Western United States. Reasons cited for channel reconfiguration include restoration to more natural or historical conditions, improved water conveyance in flood-prone areas, mitigation of unstable streambed and streambanks, increased sediment transport, and enhancement of riparian habitat. Numerous entrepreneurs and resource-management agencies have attempted to reconfigure stream and river channels using designs based on different geomorphic philosophies. However, little work has been done in assessing the channel response to, and the effectiveness of, these modifications over a period of time (Kondolf and Micheli, 1995). The U.S. Geological Survey (USGS) is engaged in a program designed to monitor and assess selected river reaches that have undergone reconfiguration.

The objectives of the USGS Reconfigured Channel Monitoring and Assessment Program (RCMAP) are:

1. To develop a uniform and versatile monitoring methodology for reconfigured channel reaches and to apply the methodology to selected reaches,
2. To create and maintain a data base consisting of numerous monumented stream reaches, and
3. To revisit these reaches periodically and assess regional and temporal trends in the geomorphic response of the stream to the channel modifications.

Long-term monitoring of reconfigured channels will allow determination of how and why a particular reconfiguration design may have remained stable or failed. This analysis will focus on understanding the processes by which a channel modification failed. These processes could include bank erosion, streambed aggradation or incision, flood-plain deposition or scour, and loss of riparian vegetation through root scour, soil-moisture deficit, or prolonged submergence.

Two-Level Approach

The RCMAP is implemented at two levels to meet the multiple objectives. Level 1 involves development of standardized sampling and monitoring methodologies, site-specific measurements, and analysis of channel characteristics. Level 2 involves long-term data-base development and periodic data-base analyses.

Level 1—Methodology and Site-Specific Analysis

Level 1 activities consist primarily of descriptive measurements of channel characteristics prior to (if possible) and following channel modification and geomorphic and hydrologic evaluations of the river reach. These measurements are tailored to a specific reach and entail surveys of the channel cross section and longitudinal profile, measurement of sediment-size characteristics of the streambed and banks, and oblique photography from monumented locations through the reach. Other measurements may include aerial-photographic interpretation and streamflow-regime analysis, if photographs and hydrologic records are available. River reaches are selected for study

and inclusion in the RCMAP data base on the basis of (1) cooperator interest and funding availability, (2) the potential for future channel-modification activity in the reach, (3) the proximity of a streamflow-gaging station, and (4) scientific research objectives.

Data are collected over a reach of at least several channel widths in length. A set of measurements is made prior to reconfiguration, if possible, and during the first year after reconfiguration. These measurements will be replicated in a subsequent year to evaluate channel change in the reconfigured reach. The interval between replicate measurements will be determined partly by the hydrologic history at the monitored reach. Some simple empirical relations also may be used to evaluate potential channel response.

Site-specific analysis provides descriptive information about a reconfigured channel reach in a timely manner and enables interested parties to assess whether the modification activities have resulted in persistent qualities deemed acceptable to land managers and the public. Another potential benefit of the USGS RCMAP is that it allows other agencies or researchers to expand upon and augment the geomorphic data gathered by the USGS. Research topics might include hydraulic function, sediment transport, aquatic habitat, and riverine ecology.

Level 2—Data-Base Development and Analysis Among Sites

The RCMAP will be expanded to include other sites representing a range of geomorphic, sedimentologic, and hydrologic stream types. RCMAP data will be archived in a manner similar to that of the USGS Vigil Network (Emmett and Hadley, 1968), and these data will be added to a USGS web site. The optimal size of the data base for subsequent analyses depends, in part, on the site-to-site variability in the data base.

The Level 2 analyses use the Level 1 data base compiled over several years to identify regional patterns or trends in channel processes and morphology and to assess the channel response to earlier modification efforts. This analysis among sites is ongoing as the data base periodically is updated and expanded. Level 2 analyses identify additional data collection or model applications needed to understand channel processes and responses at specific sites. Level 2 analyses could include (a) an evaluation of the effects of observed streamflow on post-reconfiguration channel morphology; (b) a determination of flow velocity, shear stress, and sediment entrainment potential under a range of discharges; (c) an empirical determination of sediment-transport rates to identify sites of potential aggradation or scour; and (d) parametric and nonparametric statistical analyses to evaluate whether the success rate of channel reconfiguration efforts is a function of specific channel morphology, gradient, sediment type, flow regime, and so forth.

Lake Fork of the Gunnison River: A Demonstration Site

The Lake Fork of the Gunnison River at Gateview, Colorado, was selected as a demonstration site for the RCMAP (fig. 1). Prior to reconfiguration, this reach was characterized by a wide, shallow channel with a streambed composed of gravel, cobbles, and boulders (fig. 2*A*). Aerial photography from 1977 and onsite reconnaissance in 1992 indicate that segments of the river channel had been artificially straightened. Other segments were braided and prone to bank erosion and lateral shifting. Onsite reconnaissance and landowner interviews in 1998 indicated that some segments of the channel were laterally restricted by an engineered levee (figs. 3 and 4), and possibly dredged over a period of years.

A 2-mile-long segment of the Lake Fork was reconfigured in late 1997 to mitigate past problems associated with flooding and gravel deposition on the flood plain and to improve the trout fishery. The channel modifications included (a) deepening of the channel by streambed excavation, (b) slight increases in sinuosity by constructing cobble alternate bars, (c) reduction of flow width and creation of streambank protection through addition of large cobbles and boulders to the former banks, (d) addition of streambed roughness elements and construction of grade-control and drop structures with large boulders (fig. 2), and (e) addition of vegetation root wads to riparian areas.

A 2,500-foot reach of the Lake Fork was monumented and surveyed by the USGS in September 1998. Two permanent reference marks were installed for vertical and horizontal control. The reference mark locations (latitude and longitude) were determined with a global positioning system (GPS) receiver to facilitate replication of the survey at a future date. The survey consisted of longitudinal profiles of the streambanks, terraces, and the water surface at a streamflow of approximately 220 cubic feet per second. Nine channel cross sections were surveyed in the study reach. Cross sections were selected that represented the range of channel geometry in the reach or that were in locations

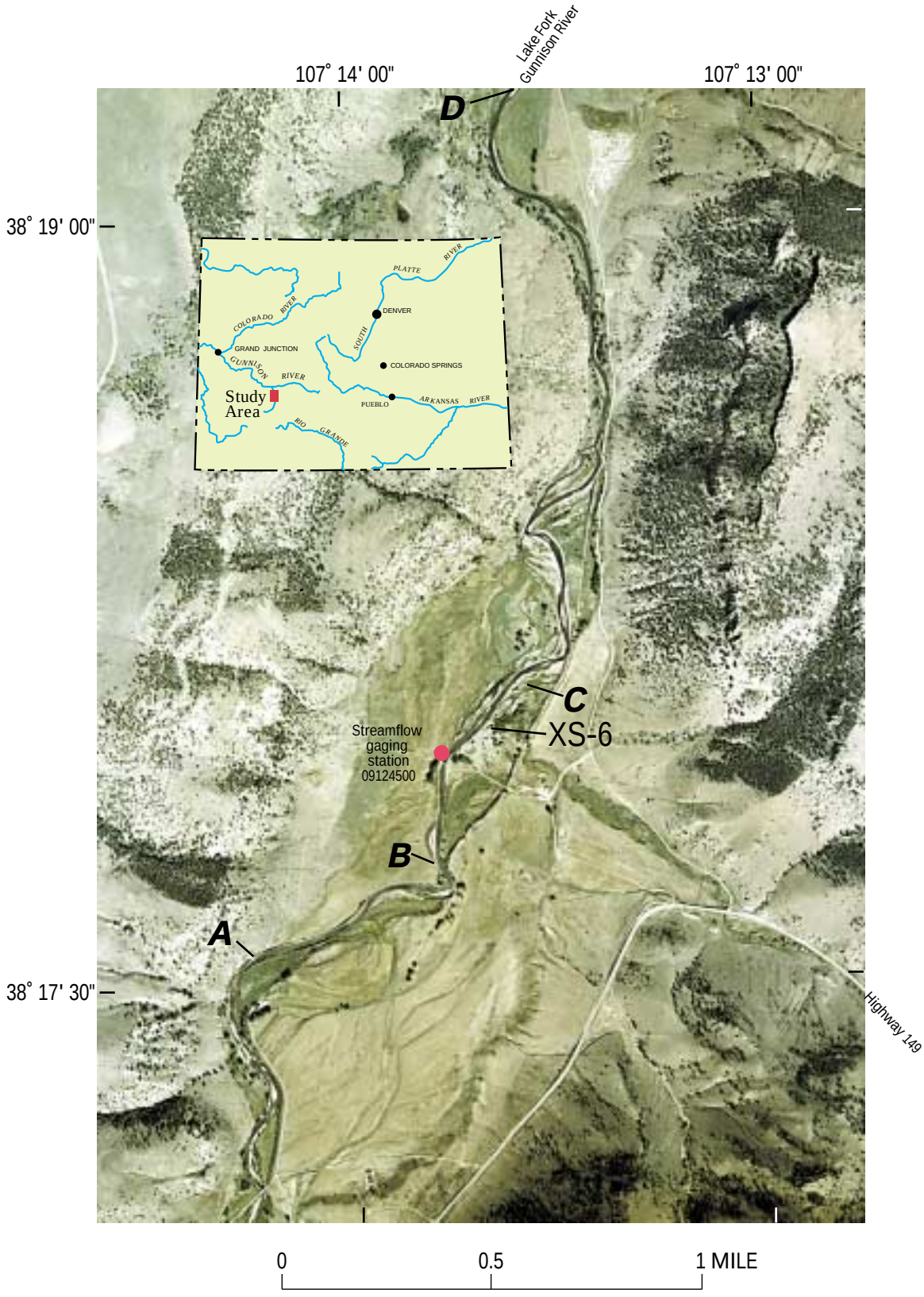

Figure 1. *Aerial photograph of the Lake Fork of the Gunnison River at Gateview, Colorado, reach taken in 1977 before channel reconfiguration activities showing location of streamflow-gaging station 09124500, reach reconstructed in 1997 (A–D), and reach monitored by U.S Geological Survey in 1998 (B–C).*

Figure 2. *Lake Fork of the Gunnison River at Gateview, Colorado. Views looking downstream to the bridge near gaging station 09124500, (A) in 1992 prior to reconfiguration at a discharge of 270 cubic feet per second, and (B) in 1998 following reconfiguration at a discharge of 230 cubic feet per second. The cobble bar forming the left bank in (B) was constructed of material dredged from the streambed to the right. The large, partly submerged boulders in the right side of the channel in (B) were quarried offsite and added to the streambed during reconfiguration.*

likely to exhibit change should future adjustments occur in cross-section dimensions. The cross-section endpoints were established on a relatively stable surface, monumented, and located with a GPS receiver (fig. 4). A detail of the planimetric map created from the survey is shown in figure 3.

The monumented reach and cross-section survey was augmented with additional measurements. Sediment characteristics of the streambed and banks were determined at eight locations along the Lake Fork study reach using the Wolman (1954) pebble-count method. Oblique photographs were taken from 23 monumented locations; these

photographs provide a means to observe and quantify changes in channel dimensions, sediment characteristics, or vegetation. Streamflow records collected by the USGS since 1938 from gaging station 09124500 Lake Fork at Gateview, within the study reach, were analyzed for flood frequency and flow-duration characteristics.

Future Proposed Efforts

Channel modification and reconfiguration projects have been considered for several other river and stream reaches in the Western United States. The RCMAP is structured to include surveys of other recently reconfigured

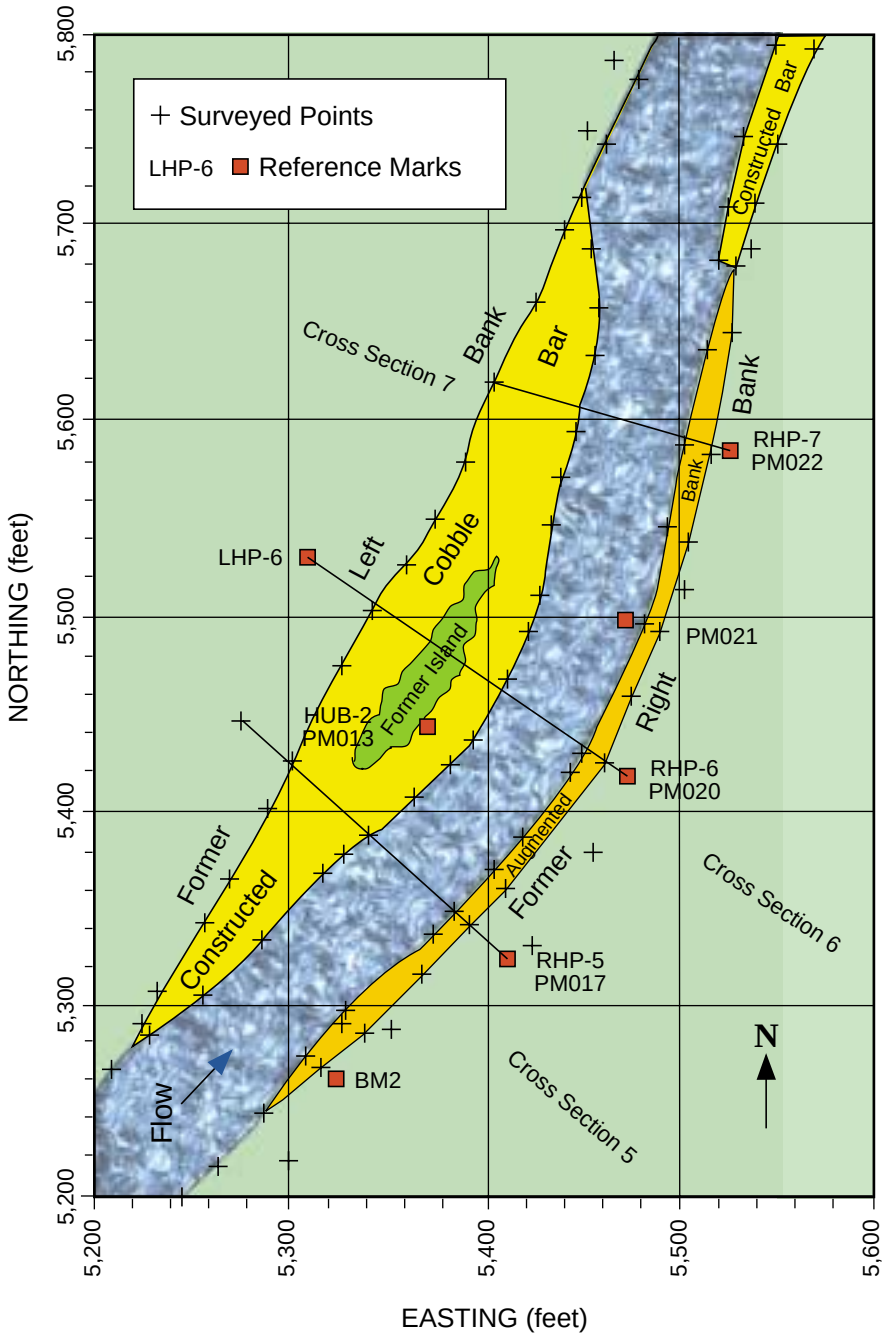

Figure 3. *Detail of the Lake Fork of the Gunnison River study-reach survey showing the reconfigured channel at a discharge of 214 cubic feet per second, monumented cross sections 5, 6, and 7, and several reference marks. Sediment composing the new right bank and the large cobble bar on the left was dredged from the streambed, producing a narrower, deeper channel.*

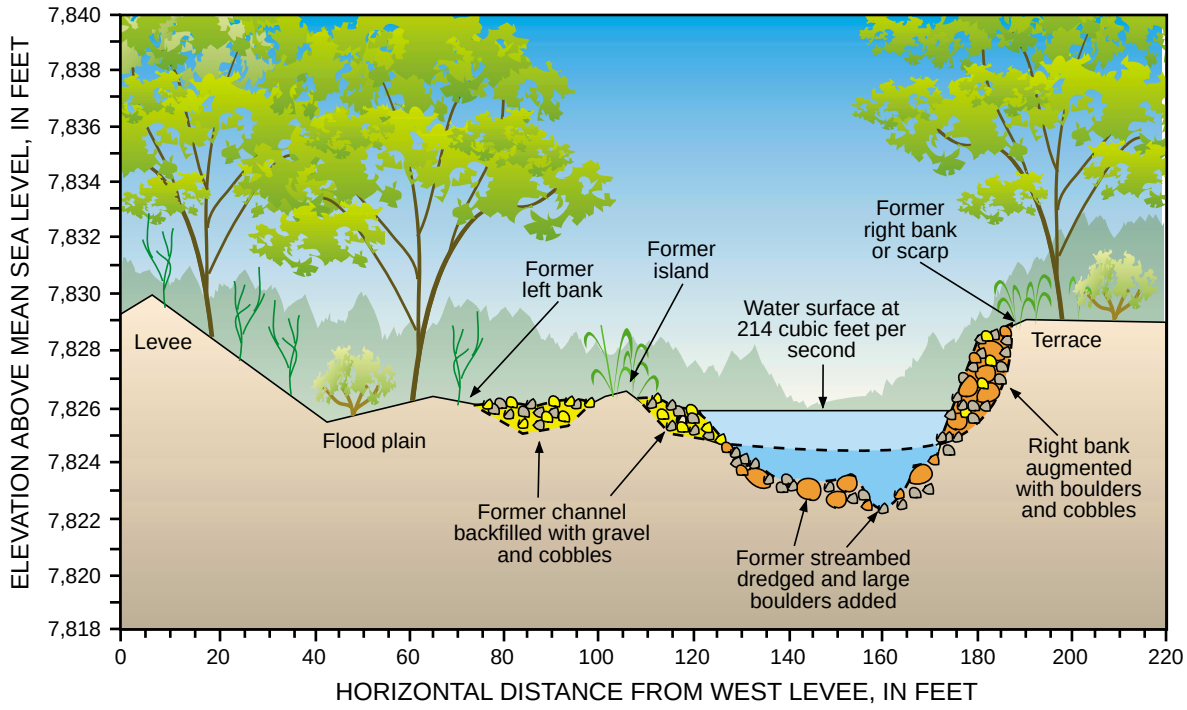

Figure 4. *Lake Fork of the Gunnison River at Gateview cross section 6 showing reconfigured channel geometry in 1998. The formerly wide and shallow channel has been narrowed and deepened by redistribution of material from the streambed to the right bank and left cobble bar.*

stream reaches and to revisit previously monumented reaches as opportunities arise. Replicate measurements at the Lake Fork monumented reach will be made to quantify changes in channel geometry and sediment-size characteristics and to determine how and why a particular reconfiguration design may have remained stable or failed. The replication interval for this and other monumented sites will be determined by local hydrologic events and by the availability of funding. Data from new river reaches and replicate surveys at previously monumented reaches also will be added to the data base and subsequently analyzed by the USGS.

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